 A/RE

03/13/98 JC525 U.S. PTO

REISSUE PATENT APPLICATION TRANSMITTAL

Attorney Docket No.: ROZMAN 6

First Named Inventor or Application Identifier: Allen Frank Rozman

Express Mail Label No.: EM006928717US

Original Patent Number. 5,528,482

Original Patent Issue Date: June 18, 1996

Address to: Assistant Commissioner of Patents and Trademarks
Box Patent Application
Washington, D.C. 20231

APPLICATION FOR REISSUE OF:
(check applicable box)

X Utility Patent ____ Design Patent ____ Plant Patent

APPLICATION ELEMENTS

X 1. Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)

X 2 Specification & Claims 12 total pages
(amended, if appropriate)

X 3. Drawing(s) 4 total pages
(proposed amendments, if appropriate)

X 4. Reissue Oath/ Declaration (original or copy) 3 total pages
(37 CFR 1.175)(PTO/SB/51 or 52)

X 5 Original U.S. Patent

X Offer to Surrender Original Patent *(37 CFR 1.178)*
(PTO/SB/53 or PTO/SB/54)

or

____ Ribboned Original Patent Grant

____ Affidavit/Declaration of Loss *(PTO/SB/55)*

X 6 Original U.S. Patent currently assigned?

X Yes ____ No
(if yes, check applicable box(es))

X Written Consent of all Assignees *(PTO/SB/53 or 54)*

X 37 CFR 3.73(b) Statement ____ Power of Attorney

ACCOMPANYING APPLICATION PARTS

____ 7. Transfer drawings from Patent File

____ 8. Foreign Priority Claim *(35 USC 119) (if applicable)*

X 9. Information Disclosure Statement (IDS)/PTO-1449
X Copies of IDS Citations

____ 10. English Translation of Reissue Oath/Declaration *(if applicable)*

____ 11. Small Entity Statement(s)
____ Statement filed in prior application, Status still proper and desired.

____ 12. Preliminary Amendment

X 13. Return Receipt Postcard *(MPEP 503)*
(Should be specifically itemized)

X 14. Other: Express Mail Certificate of Mailing

15. Correspondence Address

Address all future communications: (May only be completed by applicant, or attorney or agent of record)

David H Hitt
Hitt Chwang & Gaines, P.C.
225 University Plaza
275 West Campbell Road
Richardson, Texas 75080

March 13, 1998
Date

David H. Hitt
Registration No. 33,182

Address of signatory:

HITT CHWANG & GAINES, P.C.
225 University Plaza
275 West Campbell Road
Richardson, Texas 75080
(972) 480-8800
Fax: (972) 480-8865

____ inventor(s)
____ filed under 1.34(a)
____ assignee of complete interest
X attorney or agent of record

HITT CHWANG & GAINES, P.C.

INTELLECTUAL PROPERTY LAW & RELATED MATTERS

DAVID H HITT
T LING CHWANG, PH D
CHARLES W. GAINES

GLENN W BOISBRUN
RICHARD N MCCAIN
CHRISTOPHER D. DECLUITT

225 UNIVERSITY PLAZA
275 WEST CAMPBELL ROAD
RICHARDSON, TEXAS 75080
U S.A.

TEL· 972/480-8800
FAX: 972/480-8865
FIRM@HCG-IPLAW.COM

March 13, 1998

Commissioner of Patents
and Trademarks
Washington, D.C. 20231

Box: Reissue

Re: U.S. Patent Application
"LOW LOSS SYNCHRONOUS RECTIFIER FOR APPLICATION TO CLAMPED-MODE POWER CONVERTERS"
Case Name: ROZMAN 6

Dear Sir:

Below is our fee calculation for the above-identified reissue patent application:

FOR:	NO. FILED	NO. EXTRA	RATE	FEE
BASIC FEE			$ 790.00	$790.00
TOTAL CLAIMS	60-20=	40	$ 22.00	$880.00
INDEP. CLAIMS	8 - 3=	5	$ 82.00	$410.00
MULTIPLE DEPENDENT CLAIM PRESENTED	0		$ 270.00	$0

TOTAL $2,080.00

The Commissioner is hereby authorized to charge the fee of $2,080.00 or any additional fees that may be required to Deposit Account No. 12-2325. The undersigned does not authorize the Commissioner to charge any additional fees to the undersigned's deposit account.

Very truly yours,

HITT CHWANG & GAINES, P.C.

David H. Hitt
Registration No. 33,182

GWB/ss
Enclosures

Atty. Docket No. ROZMAN 6 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REISSUE APPLICATION

U.S. Patent No.: 5,528,482

Issued: June 18, 1996

Applicant: Allen Frank Rozman

Title: Low Loss Synchronous Rectifier For Application to Clamped-Mode Power Converters

OFFER TO SURRENDER

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

In accordance with the provisions of 37 C.F.R. §1.178, the undersigned Assignee of the accompanying reissue application for the reissue of U.S. Patent Number 5,528,482 for "Low Loss Synchronous Rectifier For Application to Clamped-Mode Power Converters," granted on June 18, 1996, to Allen Frank Rozman, and assigned to Lucent Technologies Inc. by assignment of the entire interest, hereby offers to surrender U.S. Patent Number 5,528,482 upon issuance of Letters Patent for the accompanying reissue application.

Lucent Technologies Inc.,

By: M. R. Greene
Title: Acting President - Intellectual Property

Date: 2-25-98

Atty. Docket No. ROZMAN 6 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REISSUE APPLICATION

U.S. Patent No.:	5,528,482
Issued:	June 18, 1996
Applicant:	Allen Frank Rozman
Title:	Low Loss Synchronous Rectifier For Application to Clamped-Mode Power Converters

ASSIGNEE'S ASSENT TO REISSUE

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

The undersigned Assignee is the owner of the entire interest in U.S. Patent Number 5,528,482 to Allen Frank Rozman by an Assignment that is recorded in the United States Patent and Trademark Office at Reel 7023, Frames 441-443. In accordance with the provisions of 37 C.F.R. § 1.172, the Assignee hereby consents to the filing of the accompanying reissue application and further consents to the filing of the reissue oath by the inventor thereof.

Lucent Technologies Inc.

M R Greene

By: M. R. Greene
Title: Acting President - Intellectual Property

Date: 2-25-98

LOW LOSS SYNCHRONOUS RECTIFIER FOR APPLICATION TO CLAMPED-MODE POWER CONVERTERS

This application is a [continuation in part] <u>continuation</u> of application Ser. No. 08/054,918 filed on Apr. 29, 1993 now issued as U.S. Pat. No. 5,303,138 on Apr. 12, 1994

FIELD OF THE INVENTION

This invention relates to switching type power converters and in particular to forward and flyback converters having a clamp-mode topology.

BACKGROUND OF THE INVENTION

Self synchronized rectifiers refer to rectifiers using MOSFET rectifying devices having control terminals which are driven by voltages of the windings of the power transformer in order to provide the rectification of the output of the transformer. Use of synchronous rectifiers has been limited however by the inefficiency of these rectifiers in buck derived converter topologies. Efficiency is limited due to the nature of switching of buck derived converters (i.e buck, buck-boost, boost converters including forward and flyback topologies) and due to the variability of the transformer reset voltages in the forward type converters. This variability of reset voltage limits the conduction time of one of the MOSFET rectifiers, diminishing the effectiveness and efficiency of the rectifier. This is because the rectifying devices do not conduct for the full switching period and the gate drive energy of one of the rectifiers is dissipated.

SUMMARY OF THE INVENTION

A synchronous rectifier is combined with a clamped-mode buck derived power converter. In one illustrative embodiment a hybrid rectifier includes a MOSFET rectifying device active in a first cyclic interval of the conduction/nonconduction sequence of the power switch. A second rectifying device embodied in one illustrative embodiment as a low forward voltage drop bipolar diode rectifying device is active during an alternative interval to the first conduction/nonconduction interval. The gate drive to the MOSFET device is maintained continuous at a constant level for substantially the all of the second interval by the clamping action of the clamping circuitry of the converter. This continuous drive enhances the efficiency of the rectifier.

The bipolar rectifier device may also embodied as a MOSFET device in a rectifier using two MOSFET devices. The subject rectifier may be used in both forward and flyback power converters.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic of a forward converter, of the prior art, having a synchronous rectifier;

FIG. 2 is a voltage waveform of the secondary transformer winding of the converter of FIG. 1;

FIG. 3 is a schematic of a clamped-mode forward converter with a synchronous rectifier embodying the principles of the invention;

FIG. 4 is a voltage waveform of the secondary transformer winding of the converter of FIG. 3;

FIG. 5 is a schematic of another version of a clamped-mode forward converter with a synchronous rectifier embodying the principles of the invention;

FIG. 6 is a schematic of another version of a clamped-mode forward converter with a synchronous rectifier and a center tapped secondary winding embodying the principles of the invention:

FIG. 7 is a schematic of a clamped-mode flyback converter with a synchronous rectifier embodying the principles of the invention; and

FIG. 8 is a schematic of another version of a clamped-mode forward converter with a synchronous rectifier and a center tapped secondary winding embodying the principles of the invention.

DETAILED DESCRIPTION

In the converter shown in the FIG. 1, a conventional forward topology of the prior art with an isolating power transformer is combined with a self synchronized synchronous rectifier. In such a rectifier controlled devices are used with the control terminals being driven by an output winding of the power transformer.

A DC voltage input V_{in}, at input **100**, is connected to the primary winding **110** of the power transformer by a MOSFET power switch **101**. The secondary winding **102** is connected to an output lead **103** through an output filter inductor **104** and a synchronous rectifier including the MOSFET rectifying devices **105** and **106**. Each rectifying device includes a body diode **108** and **107**, respectively.

With the power switch **101** conducting, the input voltage is applied across the primary winding **110**. The secondary winding **102** is oriented in polarity to respond to the primary voltage with a current flow through the inductor **104**, the load connected to output lead **103** and back through the MOSFET rectifier **106** to the secondary winding **102**. Continuity of current flow in the inductor **104**, when the power switch **101** is non-conducting, is maintained by the current path provided by the conduction of the MOSFET rectifier **105**. An output filter capacitor **111** shunts the output of the converter.

Conductivity of the MOSFET rectifiers is controlled by the gate drive signals provided by the voltage appearing across the secondary winding **102**. This voltage is shown graphically by the voltage waveform **201** in FIG. 2. During the conduction interval T_1 of the power switch **101**, the secondary winding voltage V_{ns1} charges the gate of MOSFET **106** to bias it conducting for the entire interval T_1. The MOSFET **105** is biased non conducting during the T_1 interval. The conducting MOSFET rectifying device **106** provides the current path allowing energy transfer to the output during the interval T_1. The gate of MOSFET rectifier **106** is charged in response to the input voltage V_{in}. All of the gate drive energy due to this voltage is dissipated.

As the power MOSFET switch **101** turns off, the voltage V_{ns1} across the secondary winding **102** reverses polarity just as the time interval T_2 begins. This voltage reversal initiates a reset of the transformer magnetizing inductance, resonantly discharges the gate of MOSFET rectifier **106** and begins charging the gate of MOSFET rectifier **105**. As shown by the voltage waveform of FIG. 2, the voltage across the secondary winding **102** is not a constant value, but is rather a variable voltage that collapses to zero in the subsequent time interval T_3, which occurs prior to the subsequent conduction interval of the power switch **101**. This voltage is operative to actually drive the rectifier **105** conducting over only a portion of the time interval T_2 which is indicated by the cross hatched area **202** associated with the waveform **201** in FIG. 2. This substantially diminishes the

performance of the rectifier **105** as a low loss rectifier device. This is aggravated by the fact that the body diode **108** of the rectifier **105** has a large forward voltage drop which is too large to efficiently carry the load current.

The loss of efficiency of the synchronous rectifier limits the overall efficiency of the power converter and has an adverse effect on the possible power density attainable. Since the synchronous rectifier **105** does not continuously conduct throughout the entire switching period, a conventional rectifier diode (e.g. connected in shunt with rectifier 105) capable of carrying the load current is required in addition to MOSFET rectifier **105**. This inefficiency is further aggravated by the gate drive energy dissipation associated with the MOSFET rectifier **106**. This gate drive loss may exceed the conduction loss for MOSFET rectifier **106**, at high switching frequency (e.g. >300 kHz).

The efficiency of a forward converter with synchronous rectification is significantly improved according to the invention by using a clamp circuit arrangement to limit the reset voltage and by using a low forward voltage drop diode in the rectifying circuitry. Such an arrangement is shown in the schematic of FIG. **3**. In this forward power converter the power MOSFET device **101** is shunted by a series connection of a clamp capacitor **321** and a MOSFET switch device **322**. The conducting intervals of power switch **101** and MOSFET device **322** are mutually exclusive. The duty cycle of power switch **101** is D and the duty cycle of MOSFET device **322** is 1-D. The voltage inertia of the capacitor **321** limits the amplitude of the reset voltage appearing across the magnetizing inductance during the non conducting interval of the MOSFET power switch **101**.

The diode **323** of the synchronous rectifier, shown in FIG. 3. has been substituted for the MOSFET device **106** shown in the FIG. **1**. Due to the dissipation of gate drive energy the overall contribution of the MOSFET rectifier **106** in FIG. **1** is limited. The clamping action of the clamping circuitry results in the constant voltage level **402** shown in the voltage waveform **401**, across the secondary winding **102**, in the time period T_2. This constant voltage applied to the gate drive of the MOSFET rectifier **105** drives it into conduction for the entire T_2 reset interval. In this arrangement there is no need for a bipolar or a body diode shunting the MOSFET rectifier **105**. An advantage in the clamped mode converter is that the peak inverse voltage applied to the diode **323** is much less than that applied to the similarly positioned MOSFET device in FIG. 1. Accordingly the diode **323** may be a very efficient low voltage diode which may be embodied by a low voltage diode normally considered unsuitable for rectification purposes.

In the operation of the clamped mode forward converter the MOSFET switch **322** is turned off just prior to turning the MOSFET power switch on. Energy stored in the parasitic capacitances of the MOSFET switching devices **101** and **322** is commutated to the leakage inductance of the power transformer, discharging the capacitance down toward zero voltage. During the time interval T_3 shown in FIG. **4**, voltage across the primary winding is supported by the leakage inductance. The voltage across the secondary winding **102** drops to zero value as shown in the FIG. 4. With this zero voltage level of the secondary winding, the output inductor resonantly discharges the gate capacitance of the MOSFET rectifying device **105** and eventually forward biases the the bipolar diode **323**. The delay time T_3 is a fixed design parameter and is a factor in the control of the power switches **101** and **322**, which may be switched to accommodate soft waveforms. This synchronous rectification circuit of FIG. 3 provides the desired efficiencies lacking in the arrangement of the circuit shown in FIG. 1.

Control of the conductivity of the power switching devices **101** and **322** is by means of a control circuit **350**, which is connected, by lead **351**, to an output terminal **103** of the converter to sense the output terminal voltage. The control circuit **350** is connected, by leads **353** and **354**, to the drive terminals of the power switches **101** and **322**. The drive signals are controlled to regulate an the output voltage at output terminal. The exact design of a control circuit, to achieve the desired regulation, is well known in the art and hence is not disclosed in detail herein. This control circuit **350** is suitable for application to the converters of FIGS. **5**,**6**,**7** and **8**.

A modified version of the circuit of FIG. **3** is shown in the circuit schematic of the FIG.**5**. The converter of FIG. **5** is a clamped mode forward converter having two gated synchronous rectifying devices **105** and **106**. In this embodiment of the synchronous rectifier the synchronized rectifying device **106** can be used without adversely affecting the converter efficiency at lower operating frequencies.

The circuit of FIG. **6** is a clamped mode forward converter having a rectifier analogous to that of FIG. **3** in using one bipolar rectifying diode. The secondary winding is tapped creating two secondary winding segments **603** and **602**.

The converter of FIG. **7** operates in a flyback mode. The bipolar and synchronous rectifier device are in a reversed connection from the connection of FIG. **3** to accommodate the flyback operation.

In some applications direct application of the gate drive signal directly from the secondary winding may result in voltage spikes exceeding the rating of the gate. A small signal MOSFET device **813** is connected to couple the gate drive to the MOSFET rectifying device **105**. This device may be controlled by the control drive lead **815** to limit the peak voltage applied to the gate of rectifier **105**. The MOSFET synchronous rectifier is then discharged through the body diode of the MOSFET device **813**.

I claim:

1. In a power converter, comprising:

an input for accepting a DC voltage;

a power transformer including a primary and secondary winding;

a power switch for periodically connecting the input to the primary winding;

an output for accepting a load to be energized;

clamping means for limiting a voltage and extending the voltage's duration across the secondary winding at a substantially constant amplitude during substantially an entire extent of a clamping interval of a cyclic period of the power converter;

a rectifier circuit connecting the secondary winding to the output; and including:

a synchronous rectification device with a control terminal connected to be responsive to a signal across the secondary winding such that the synchronous rectification device conducts a load current during substantially the entire extent of the clamping interval; and

a rectifying device connected for enabling conduction of the load current during a second interval other than the clamping interval.

2. In a power converter, comprising

an input for accepting a DC voltage;

a power transformer including a primary and secondary winding;

a power switch for periodically connecting the input to the primary winding during a second interval of a cyclic period;

an output for accepting a load to be energized;

clamping means for limiting a voltage and extending the voltage's duration across the secondary winding at a substantially constant amplitude during substantially an entire extent of a clamping interval of a cyclic period of the power converter;

a rectifier circuit connecting the secondary winding to the output; and including:

a first synchronous rectification device with a control terminal connected to be responsive to a signal across the secondary winding such that the synchronous rectification device conducts a load current during substantially the entire extent of the clamping interval, and

a second synchronous rectification device with a control terminal connected to be responsive to a signal across the secondary winding such that the second synchronous rectification device conducts the load current during substantially an entire extent of the second interval other than the clamping interval.

3. In a power converter as claimed in claim 1 or 2, comprising:

the converter connected to operate as a forward type converter.

4. In a power converter as claimed in claim 1 or 2, comprising:

the converter connected to operate as a flyback type converter.

5. A switching mode power converter, comprising:

a power transformer including a magnetizing inductance requiring periodic recycling;

a first power stage for converting a DC input into a periodic pulsed voltage applied to a primary winding of the transformer, including:

a clamping circuit for limiting a voltage of the transformer during the periodic recycling at a substantially constant amplitude and extending the voltage duration to maintain a constant voltage for substantially an entire extent of periodic recycling;

a second power stage for rectifying an output o[illegible]econdary winding of the transformer and applying it to a load to be energized, including:

a synchronous rectifier including a first rectifying device with a control gate connected to be responsive to a signal across the secondary winding such that the synchronous rectification device conducts a load current during the periodic recycling when the clamping circuit is active, and

a second rectifying device connected for enabling conduction of the load current when the first rectifying device is nonconducting.

6. A switching mode power converter as claimed in claim 5, further comprising:

the second rectifying device comprises a diode.

7. A switching mode power converter as claimed in claim 5, further comprising:

the second rectifying device comprises a rectifying device with a control gate connected to be responsive to a signal of the secondary winding.

8. A switching mode power converter as claimed in claim 6 or 7, further comprising:

the secondary winding tapped and separated into first and second winding segments, and the first rectifying device is connected to the first winding segment and the second rectifying device is connected to the second winding segment.

9. A switching mode power converter as claimed in claim 6 or 7, further comprising:

the converter connected to operate as a forward type converter.

10. A switching mode power converter as claimed in claim 6 or 7, further comprising:

the converter connected to operate as a flyback type converter.

Please add Claims 11-60:

11. A power converter, comprising:

a power transformer having a plurality of windings;

a clamping circuit, coupled to said power transformer, that limits a voltage across at least one of said plurality of windings during a clamping interval of said power converter; and

a synchronous rectification device coupled to said power transformer and having a control terminal responsive to a signal across at least one of said plurality of windings such that said synchronous rectification device is active for substantially all of said clamping interval.

12. The power converter as claimed in claim 11 wherein said clamping circuit is directly connected to said power transformer.

13. The power converter as claimed in claim 11 wherein said clamping circuit is coupled to a primary winding of said power transformer.

14. The power converter as claimed in claim 11 wherein said power transformer has a center-tapped secondary winding.

15. The power converter as claimed in claim 11 further comprising a power switch that connects a primary winding of said power transformer to an input of said power converter during a first cyclic interval of said power converter.

16. The power converter as claimed in claim 11 further comprising a further synchronous rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

17. The power converter as claimed in claim 11 further comprising a rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

18. The power converter as claimed in claim 11 wherein said clamping circuit comprises a switching device connected in series with a capacitor.

19. The power converter as claimed in claim 18 further comprising a control circuit that controls said switching device.

20. The power converter as claimed in claim 11 wherein said power converter operates in one of:

a forward mode,

a flyback mode, and

a forward/flyback mode.

21. A power converter, comprising:

a power transformer having a plurality of windings;

a synchronous rectification device coupled to at least one of said plurality of windings and having a control terminal; and

a clamping circuit, coupled to said power transformer, that limits a voltage applied to said control terminal such that said synchronous rectification device is active for substantially all of a clamping interval.

22. The power converter as claimed in claim 21 wherein said clamping circuit is directly connected to said power transformer.

23. The power converter as claimed in claim 21 wherein said clamping circuit is coupled to a primary winding of said power transformer.

24. The power converter as claimed in claim 21 wherein said power transformer has a center-tapped secondary winding.

25 The power converter as claimed in claim 21 further comprising a power switch that connects a primary winding of said power transformer to an input of said power converter during a first cyclic interval of said power converter.

26. The power converter as claimed in claim 21 further comprising a further synchronous rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

27. The power converter as claimed in claim 21 further comprising a rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

28. The power converter as claimed in claim 21 wherein said clamping circuit comprises a switching device connected in series with a capacitor.

29. The power converter as claimed in claim 28 further comprising a control circuit that controls said switching device.

30. The power converter as claimed in claim 21 wherein said power converter operates in one of:

a forward mode,

a flyback mode, and

a forward/flyback mode.

31. A power converter, comprising:

a power transformer having a plurality of windings;

a synchronous rectification device having a control terminal and coupled to at least one of said plurality of windings; and

a clamping circuit, coupled to said power transformer, that limits a voltage applied to said control terminal such that said synchronous rectification device conducts a load current for substantially all of a clamping interval.

32. The power converter as claimed in claim 31 wherein said clamping circuit is directly connected to said power transformer.

33. The power converter as claimed in claim 31 wherein said clamping circuit is coupled to a primary winding of said power transformer.

34. The power converter as claimed in claim 31 wherein said power transformer has a center-tapped secondary winding.

35 The power converter as claimed in claim 31 further comprising a power switch that connects a primary winding of said power transformer to an input of said power converter during a first cyclic interval of said power converter.

36. The power converter as claimed in claim 31 further comprising a further synchronous rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

37. The power converter as claimed in claim 31 further comprising a rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

38. The power converter as claimed in claim 31 wherein said clamping circuit comprises a switching device connected in series with a capacitor.

39. The power converter as claimed in claim 37 further comprising a control circuit that controls said switching device.

40. The power converter as claimed in claim 31 wherein said power converter operates in one of:

a forward mode,

a flyback mode, and

a forward/flyback mode

41. A power converter, comprising:

a power transformer having a plurality of windings;

a synchronous rectification device having a control terminal responsive to a drive signal and coupled to at least one of said plurality of windings; and

a clamping circuit, coupled to said power transformer, that limits said drive signal applied to said control terminal such that said drive signal is continuous for substantially all of a clamping interval.

42. The power converter as claimed in claim 41 wherein said clamping circuit is directly connected to said power transformer.

43 The power converter as claimed in claim 41 wherein said clamping circuit is coupled to a primary winding of said power transformer.

44. The power converter as claimed in claim 41 wherein said power transformer has a center-tapped secondary winding.

45. The power converter as claimed in claim 41 further comprising a power switch that connects a primary winding of said power transformer to an input of said power converter during a first cyclic interval of said power converter.

46. The power converter as claimed in claim 41 further comprising a further synchronous rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

47. The power converter as claimed in claim 41 further comprising a rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

48. The power converter as claimed in claim 41 wherein said clamping circuit comprises a switching device connected in series with a capacitor.

49. The power converter as claimed in claim 48 further comprising a control circuit that controls said switching device.

50. The power converter as claimed in claim 41 wherein said power converter operates in one of:

a forward mode,

a flyback mode, and

a forward/flyback mode.

51. A power converter, comprising:

an input that accepts a DC voltage;

an output that provides current to a load;

a power transformer having at least one primary winding and at least one secondary winding;

a power switch that periodically connects said input to said at least one primary winding during a first cyclic interval of said power converter;

a clamping circuit that limits a voltage across said at least one secondary winding during a clamping interval of said power converter; and

a synchronous rectification device having a control terminal responsive to a signal across said at least one secondary winding such that said synchronous rectification device is active for substantially all of said clamping interval.

52. The power converter as claimed in claim 51 wherein said clamping circuit is directly connected to said power transformer.

53. The power converter as claimed in claim 51 wherein said clamping circuit is coupled to said at least one primary winding of said power transformer.

54. The power converter as claimed in claim 51 wherein said at least one secondary winding has a center-tap.

55. The power converter as claimed in claim 51 further comprising a voltage limiting device coupled to said synchronous rectification device.

56. The power converter as claimed in claim 51 further comprising a further synchronous rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

57. The power converter as claimed in claim 51 further comprising a rectification device, coupled to said power transformer, that is active during a first cyclic interval of said power converter.

58. The power converter as claimed in claim 51 wherein said clamping circuit comprises a switching device connected in series with a capacitor.

59. The power converter as claimed in claim 58 further comprising a control circuit that controls said switching device.

60. The power converter as claimed in claim 51 wherein said power converter operates in one of:

a forward mode,

a flyback mode, and

a forward/flyback mode.

ABSTRACT

A synchronous rectifier for use with a clamped-mode power converter uses in one embodiment a hybrid rectifier with a MOSFET rectifying device active in one first cyclic interval of the conduction/nonconduction sequence of the power switch and a second rectifying device embodied in one illustrative embodiment as a low voltage bipolar diode rectifying device active during an alternative interval to the first conduction/nonconduction interval. The gate drive to the MOSFET device is continuous at a constant level for substantially all of the second interval which enhances efficiency of the rectifier. The bipolar rectifier device may also be embodied as a MOSFET device. The subject rectifier may be used in both forward and flyback power converters.

Atty. Docket No. ROZMAN 6

PATENT

OIPE JUN 08 1998 JC14 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REISSUE APPLICATION

U.S. Patent No.:	5,528,482
Issued:	June 18, 1996
Applicant:	Allen Frank Rozman
Title:	Low Loss Synchronous Rectifier For Application to Clamped-Mode Power Converters

CERTIFICATE UNDER 37 C.F.R. 3.73(b)

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

Lucent Technologies Inc., a Delaware corporation, certifies that it is the Assignee of the entire right, title and interest in the patent application identified above by virtue of an Assignment from Allen Frank Rozman to AT&T Corp. that is recorded in the United States Patent and Trademark Office at Reel 7023, Frames 441-443 and by a subsequent Assignment from AT&T Corp. to Lucent Technologies Inc. that is recorded in the United States Patent and Trademark Office at Reel 8102, Frame 0142. The undersigned is empowered to sign this Certificate on behalf of the Assignee.

Lucent Technologies Inc.,

By: [signature]
M. R. Greene
Title: Acting President - Intellectual Property

Date: 5-27-98

Atty. Docket No. ROZMAN 6

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REISSUE APPLICATION

U.S. Patent No.:	5,528,482
Issued:	June 18, 1996
Applicant:	Allen Frank Rozman
Title:	Low Loss Synchronous Rectifier For Application to Clamped-Mode Power Converters

SUPPLEMENTAL ASSENT OF THE ASSIGNEE TO REISSUE

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

The undersigned Assignee is the owner of the entire interest in U.S. Patent Number 5,528,482 to Allen Frank Rozman. The right of ownership is established by virtue of an Assignment from Allen Frank Rozman to AT&T Corp. that is recorded in the United States Patent and Trademark Office at Reel 7023, Frames 441-443 and by a subsequent Assignment from AT&T Corp. to Lucent Technologies Inc. that is recorded in the United States Patent and Trademark Office at Reel 8102, Frame 0142. In accordance with the provisions of 37 C.F.R. §1.172, the Assignee hereby consents to the filing of the accompanying reissue Application and further consents to the filing of the reissue Declaration by the inventor thereof.

Lucent Technologies Inc.,

By: M R Greene

M. R. Greene
Title: Acting President - Intellectual Property

Date: 5-29-98

FIG. 1
(PRIOR ART)

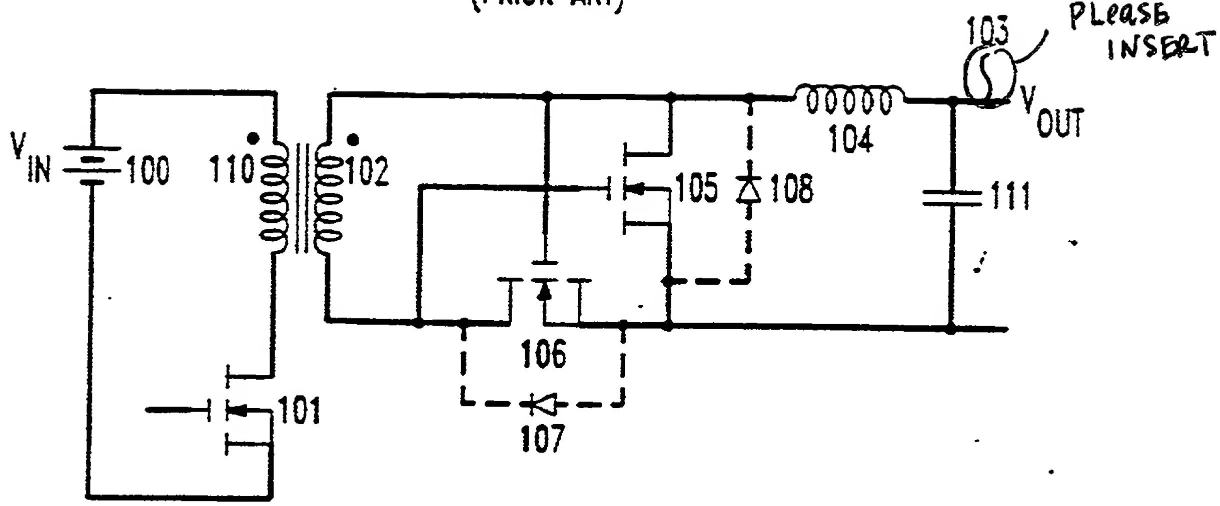


FIG. 2
(PRIOR ART)

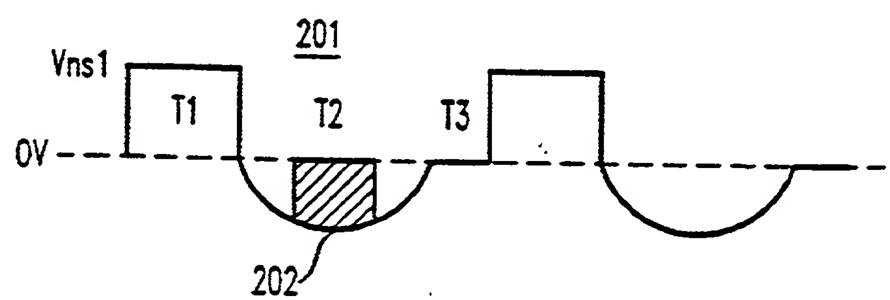
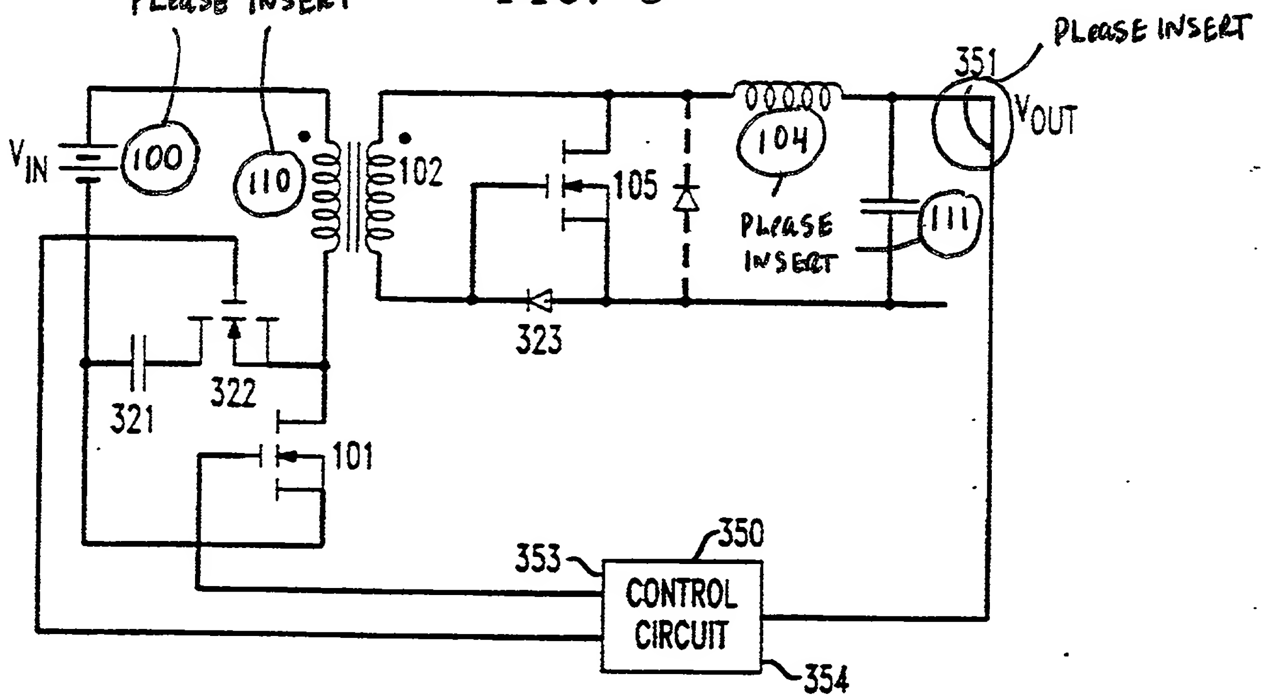


FIG. 3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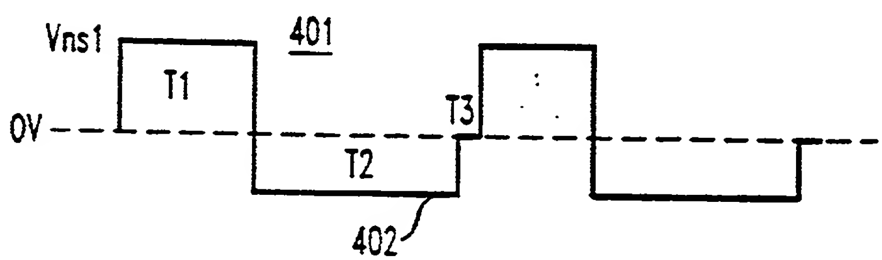
CONTROL CIRCUIT
354

FIG. 4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402

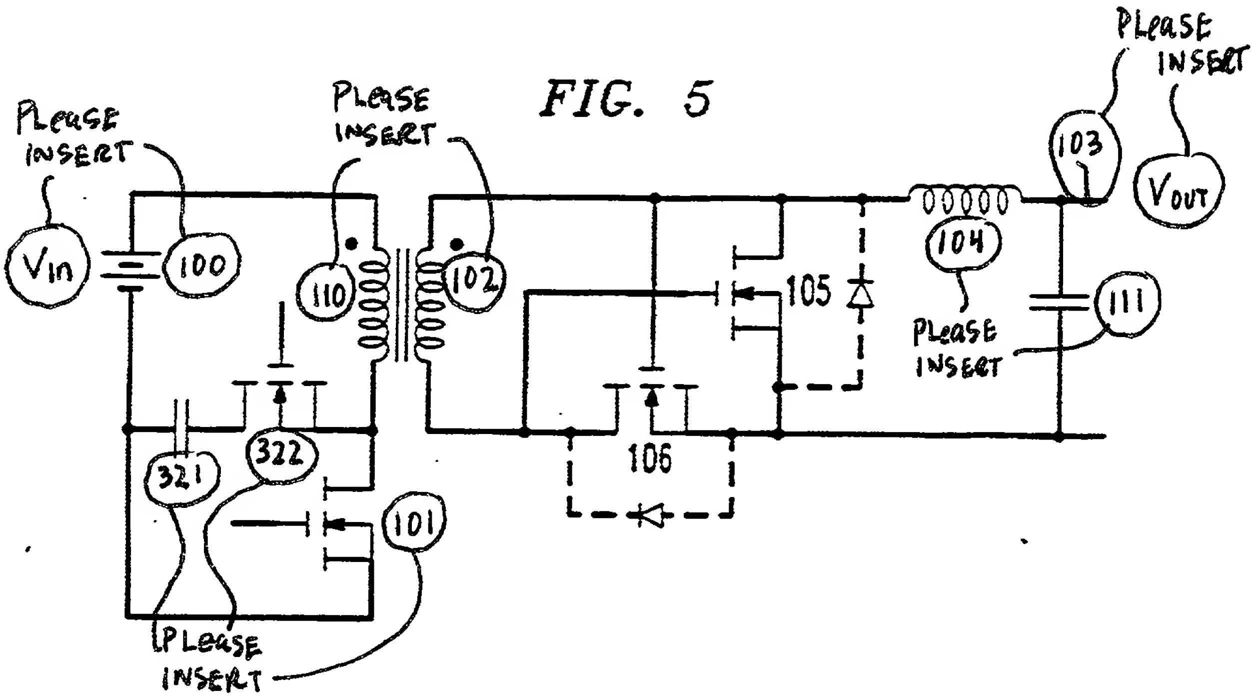
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FIG. 5

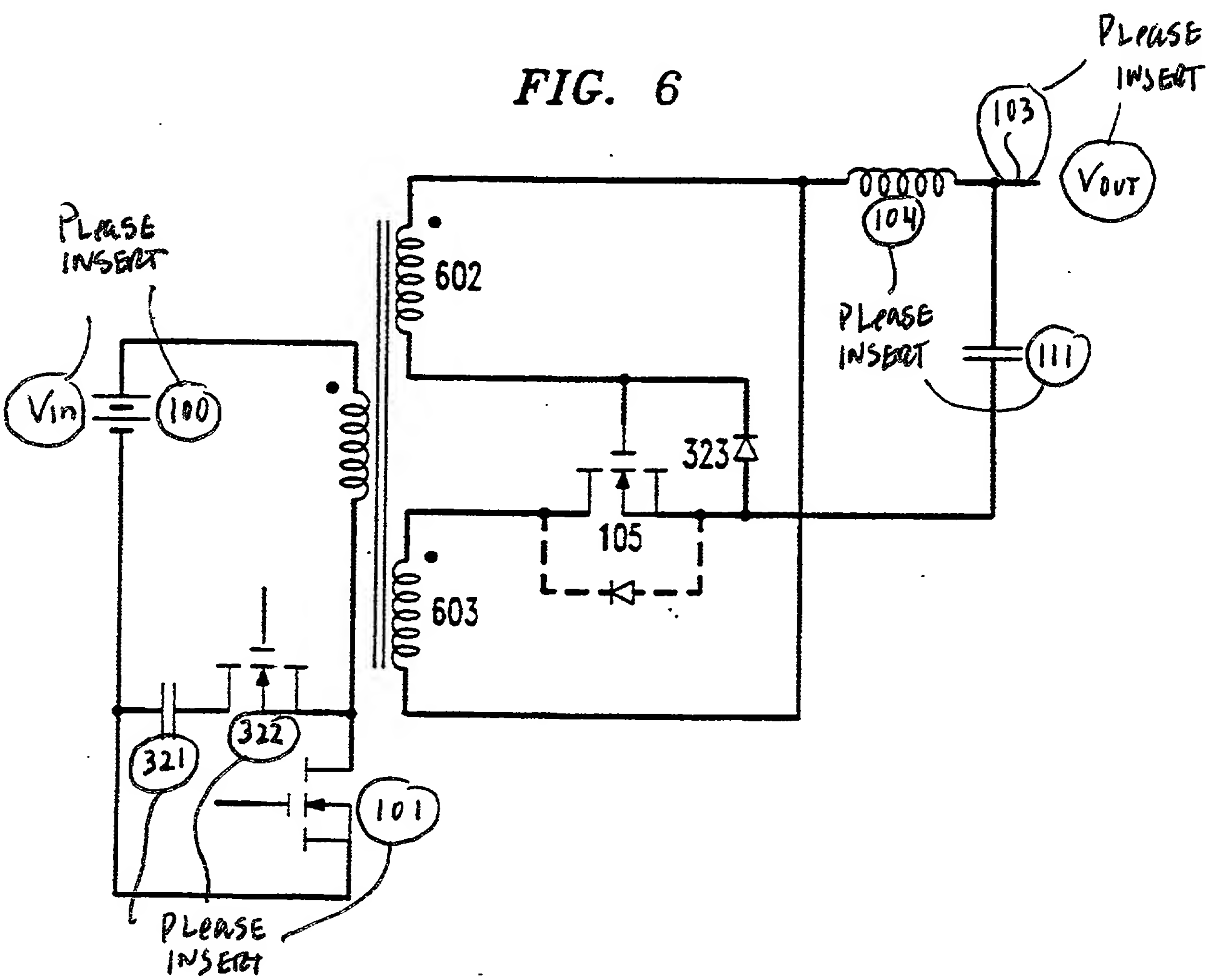
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FIG. 6

FIG. 7

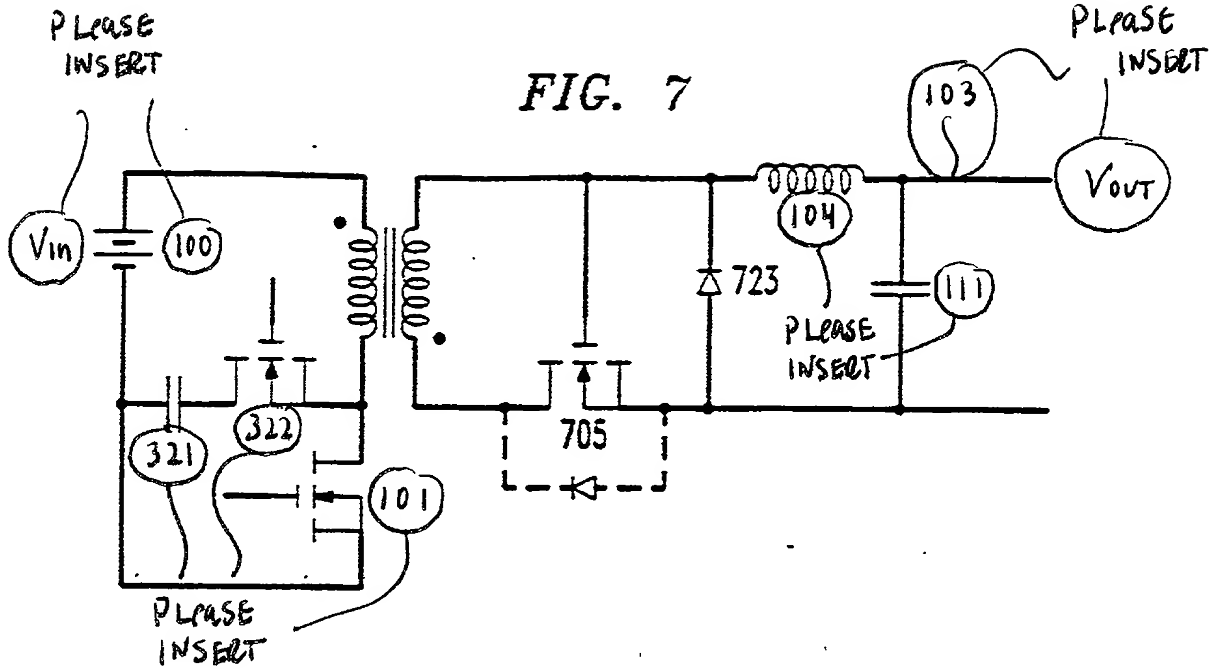
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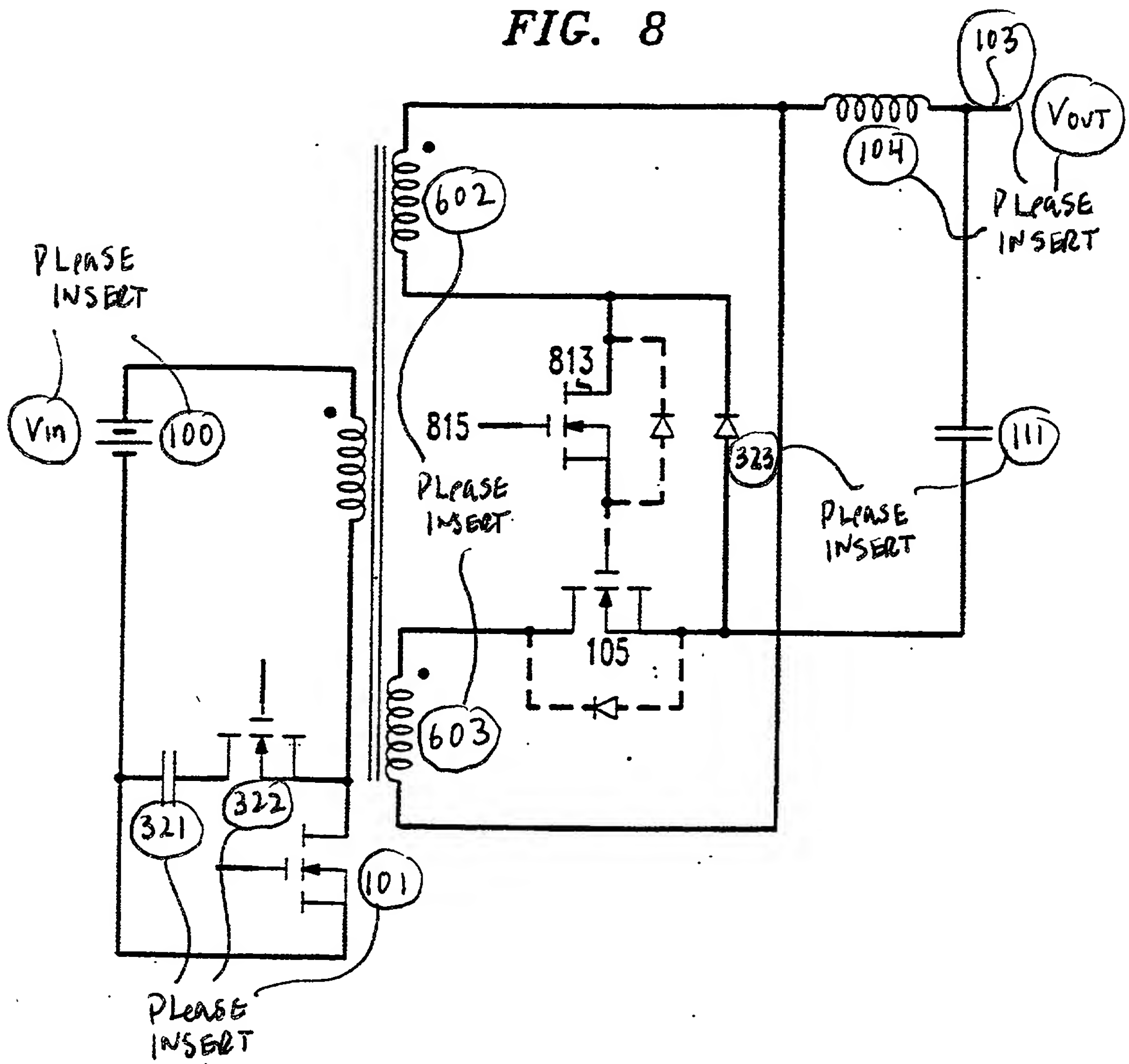
FIG. 8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Vout

Atty. Docket No. ROZMAN 6 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REISSUE APPLICATION

U.S. Patent No.:	5,528,482
Issued:	June 18, 1996
Applicant:	Allen Frank Rozman
Title:	Low Loss Synchronous Rectifier for Application to Clamped-Mode Power Converters

DECLARATION

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Box: Reissue

Sir:

As the below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name and that I believe that I am the original and first inventor of the subject matter which is described and claimed in the U.S. Patent No. 5,528,482, granted June 18, 1996, and for which a reissue patent is sought on the invention entitled: "Low Loss Synchronous Rectifier for Application to Clamped-Mode Power Converters," the specification of which is attached hereto.

I have reviewed and understand the contents of the above identified specification, including the claims.

I acknowledge the duty to disclose information that is material to the examination of this application in accordance with 37 C.F.R. §1.56.

I believe that the original patent is wholly or partly inoperative or invalid by reason of a defective declaration and that the error arose without any deceptive intention. The declaration was defective on its face since the application was inadvertently identified as a continuation-in-part rather than a continuation.

I further believe that the original patent is wholly or partly inoperative or invalid by reason of defective drawings and that the errors arose without any deceptive intention. More specifically, reference numerals were inadvertently omitted from several figures. The specification clearly supports the addition of the reference numerals and no new matter is introduced. The corrections are indicated in the drawings submitted in the reissue application.

I further believe that the original patent is wholly or partly inoperative by reason of claiming less than I had the right to claim in the patent and that the error arose without any deceptive intention. I believe that the scope of Claims 1-10 is unnecessarily narrow in light of what is disclosed in U.S. Patent Number 5,528,482.

New independent Claims 11, 21, 31, 41 and 51, as presented in the reissue application, are broader in scope. The new claims more particularly point out and distinctly claim the invention in U.S. Patent Number 5,528,482. The new claims do not introduce new matter since the specification, which has not been changed, directly supports the new claims.

New Claims 12-20, 22-30, 32-40, 42-50 and 52-60, as presented in the reissue application, are dependent on new independent Claims 11, 21, 31, 41 and 51, and therefore include the limitations of the new independent Claims. No new matter is introduced.

All the errors corrected in this reissue application arose without any deceptive intention on my part.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application, or any patent issuing thereon, or any patent to which this declaration is directed.

Full name of inventor: Allen Frank Rozman

Residence and Post Office Address:

1702 Waverly Court
Richardson, Texas 75082

Citizenship: United States of America

Inventor's signature: Allen F Rozman Date: 3-12-98